Preparing for extended space flight: nutrition and the human body

As lengthy stays aboard the International Space Station loom in the near future, and plans for potential missions to Mars begin to unfold, the need for a better understanding of nutritional requirements for astronauts during extended-duration space flight becomes evident.

Nutrition is key to maintaining physiology on the ground, and it is even more critical in flight. The responsibility for overseeing this critical area is that of the scientists in the JSC Nutritional Biochemistry Laboratory, whose charge is to define nutritional requirements for space flight–that is, determine how many calories and other nutrients a crewmember needs in a given day, and how these requirements are altered in flight versus on the ground.

Current issues of primary concern to the researchers involve the astronauts' dietary intake, bone loss, and iron absorption in space.

Diet

"A problem that we've seen repeatedly in flight is that the crewmembers do not eat as much as we'd like them to, and that's our first concern," said Dr. Scott M. Smith, lead for the JSC Nutritional Biochemistry Laboratory.

Crewmembers typically eat a high carbohydrate diet, and proportions of macronutrients (i.e., protein, carbohydrate, and fat) generally meet standard recommendations. However, food and fluid intake decrease during space flight, despite the fact that pre-flight and in-flight energy requirements are the same. The balance between energy intake and energy expenditure regulates body weight. In space flight, where intake is often reduced and expenditure is unchanged or increased, there is a loss of body mass. This may have significant effects on medical and research studies, and also affect crew health.

As space flight evolves from short-duration space shuttle missions to extended habitation aboard the ISS, NASA will be challenged to provide astronauts with more palatable and more nutritious food. The development of advanced food technologies is essential for successful long-duration missions.

Toward that end, NASA recently selected Iowa State University to head up research that could lead to better food for astronauts and safer, more nutritious packaged foods for everyone. Iowa State will head the National Food Technology Commercial Space Center, working to improve food for long-duration space missions and to enhance the packaging, preparation and storage of commercially produced food.

JSC will sponsor the commercial space center. Commercial partners in the center will provide additional resources in a collaborative effort to develop the new technologies.

Improvements in the shelf life and safety of food for space flight could lead to similar improvements in commercially produced and packaged food available to the public. Partnerships with the private sector will be essential elements of the Food Technology Commercial Space Center, in addition to the academic institution's own resources.

"A consortium of universities and companies in the food processing industry will work with NASA to ensure that the foods that are developed will be usable for both space and terrestrial purposes," said Dr. Dennis Olson, director of the center. "Diminishing the weight of foods to be carried into space and decreasing the amount of waste produced are important concerns. Of course palatability is of key importance."

Nutrients studied in space flight include water, sodium, potassium, calories, protein, calcium, and iron. Water is extremely important to maintain hydration and is essential to prevent the space flight medical problem of kidney stone formation. Astronauts frequently do not drink enough. They need at least eight cups of fluids from drinks and food. Without adequate calories and protein, the astronauts cannot maintain their muscle strength and actually lose muscle tissue. Obviously this is important for good health and performance during space flight and critical for space walks and returning to Earth.

Furthermore, calories, protein, and calcium are essential for bone health. Water, sodium and potassium are essential for cardiovascular function. Research with these nutrients has been completed throughout the human space program with recent work on STS-95 and the Shuttle-Mir program. Further work will be completed on upcoming shuttle flights and aboard the ISS.

Bone Loss

The ability to understand and counteract weightlessness-induced bone loss remains a critical issue for astronaut health and safety during and after extended-duration exploration missions.

"Bone loss is one of the more critical problems that we face in preparing crews for long-duration missions," said Smith. "A number of other changes occur during short-duration space flight, including vestibular and cardiovascular changes, but those tend to be more acute and tend to be more of immediate impact during re-entry, landing, and in the first days to weeks after the mission."

Calcium is lost from bones during space flight due to skeletal unloading and insufficient levels of vitamin D. Vitamin D

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Dr. Helen W. Lane demonstrates the conversion of rice grains to food products that will be used for advanced life support. These types of foods will be processed during the BIO-PLEX test bed being built by the Engineering Directorate in Bldg. 29. Also, illustrated is the upcoming NASA book that is an anthology of nutritional research during space flight from the early 1970s to the recent NASA-Mir missions.